IL-178-11

Shell Oil Company
Interoffice Memorandum

NOVEMBER 4, 1981

FROM: GEOLOGIST, ENVIRONMENTAL AFFAIRS

TO: TECHNICAL SUPERINTENDENT, WOOD RIVER MANUFACTURING COMPLEX

SUBJECT: GROUNDWATER MULTILEVEL PIEZOMETER STUDY, WOOD RIVER MANUFACTURING COMPLEX

Introduction

In an attempt to determine if groundwater in the vicinity of the old fly ash pond (OFAP) was being properly managed, a multilevel piezometer network was installed. Data from this network aided in defining groundwater equipotential and quality. Groundwater equipotential maps provide a 2-dimensional view of groundwater flow in cross section (perpendicular to the hydraulic gradient). The equipotential maps combined with the groundwater table map provide 3-dimensional evaluation of the aquifer.

Refinery waste streams were disposed into the OFAP (Fig. 1) in the past. More recently, the solid waste disposal basin (SWDB), immediately adjacent to the OFAP, has been utilized (Fig. 1). This report will serve to document that seepage from the disposal area (OFAP and SWDB) is being contained by the North Property pumping wells, and will continue to be contained as long as the cone of depression is maintained.

Piezometer Design and Installation

Piezometers are small diameter (≤2 inches) groundwater monitoring devices which are screened and sealed over a short interval (~2 feet) within an aquifer. In order to maximize information at each drilling location, two piezometers were installed in each borehole (i.e., multilevel piezometers). By setting the piezometers at discrete depths within the aquifer, obtained data was used to construct equipotential maps (Fig's. 2 & 3).

Equipotential lines connect points of equal hydraulic head and are constructed in cross section, perpendicular to the water table or potentiometric gradient. If a piezometer is screened at any point along an equipotential line, then the hydraulic head measured in the piezometer will be the same everywhere along the line. Analysis of equipotential maps provides information on verticle flow gradients within an aquifer. Phenomena such as underflow (horizontal flow beneath a pumping well), recharge gradients, and discharge gradients can then be observed.

Piezometer locations (Fig. 1) were selected so that contaminant plumes originating from the OFAP area could be adequately monitored. A total of 24 piezometers were installed. An upper and lower piezometer was installed in each of the 12 boreholes. Two lines of piezometers (A-A', B-B') provide information for the construction of the equipotential maps. Line C-C' was used to provide additional geohydrological correlation (Fig. 4) and water quality data. The piezometer pair P-12 was used to provide threshold (up-dip) water quality data and for geologic control.

After the piezometers were installed, they were developed by an air surge method. A small diameter stainless steel U-tube was lowered to the bottom of each piezometer. Surging with compressed air then removed any water and "fines" which may have entered the piezometer. Please refer to the October 9, 1980 memorandum (Attachment I) for further details of the piezometer design and installation.

Geohydrology

The Wood River refinery lies on the Wood River terrace (within the Mississippi meander belt) and is bounded on the west by the Mississippi River and on the east by the Kendall Hill bluffs. At the end of Pleistocene time, glacial outwash (Mackinaw Member of the Henry Formation) was deposited by the ancestoral Mississippi River which carried vast amounts of meltwater from receding glaciers. Loess (Peoria Loess and Roxana Silt) was carried by wind from the floodplains and deposited upon the glacial outwash.

During postglacial time, fluvial sediments (such as channel, point bar, natural levee, and floodplain sequences) were deposited where the Mississippi and its tributaries eroded through the older outwash deposits. These more recent sediments are known as the Cahokia Alluvium. Unconsolidated deposits (Fig. 5) overlie limestone bedrock which occurs at depths ranging from 110 to 170 feet below grade (Fig's. 2-4).

General geologic logs (Attachment II) obtained during drilling indicate that sediments within the study area consist of clays, silty to fine grained sands, and medium to coarse grained sands. In general, the upper 15 feet consists of clays and silts. Below these relatively impermeable deposits, sands are encountered which coarsen with depth. Some of the sands contain interbedded silts and clays. The underlying clay appears to be the weathered portion of the limestone bedrock. Thickness of the lower clay varies from 2 to 30 feet.

The surface boundary between the glacial outwash deposits and the alluvium appears to occur between P_1 and P_2, and between P_5 and P_7. Piezometers P_1, P_7, and P_{12} appear to be located in alluvium, while the remainder appear to be in glacial outwash. Due to the rotary drilling method utilized to install the piezometers, a detailed geologic cross section can not be constructed.

The uppermost aquifer in this area is unconfined and occurs in the outwash and alluvial sediments. Depth to the water table ranges between 20 and 45 feet (depending on location and time of year), while depth to the lower clay ranges between 80 and 130 feet (Figs. 2-4). The clay is the lower boundary of the unconfined aquifer. Sediments in this study area are heterogeneous and anisotropic. None of the interbedded clays extend far enough laterally to form a confining layer, but may cause local perturbations or anomalies in groundwater flow. Locally, small perched water tables may occur, but are not significant.

In the study area, recharge to the aquifer occurs by infiltration at the base of the bluffs and by percolation of rainwater through overlying sediments. A groundwater table map (Fig. 6) shows the hydraulic gradient (≅ 1'/250') to be dipping to the west. Groundwater flow paths originating from the disposal area merge toward the center of the cone of depression on the North Property formed by the combined pumping effects of the water extraction wells. Permeabilities (based on Hazen's d_{10} approximation) range from approximately $1x10^{-7}$ cm/sec in some of the clays to approximately $5x10^{-2}$ cm/sec in the fine to medium grained sands.

The equipotential maps were constructed with data transmitted by D. Domino on September 1, 1981, (Attachment III). Analysis of the equipotential maps shows that in the upper half of the aquifer, groundwater flow is essentially horizontal. Groundwater flow in the lower half of the aquifer appears to conform to the bedrock surface (Fig's. 2 & 3). Transmissivity anomalies occur between piezometers P_8 and P_6 and between piezometers P_4 and P_3. The anomalies are related to lithology changes at these points, probably associated with the glacial outwash and alluvium interface. A slight upward component of groundwater flow occurs at P_9. Upward flow at this point could be due to either 1) a rise in bedrock, or 2) hydraulic effects due to pumping well operations. Additional generalized geohydrological information can be found in the Dames and Moore Phase II site Investigation dated April 14, 1981.

Water Quality

A groundwater sampling program was developed to obtain meaningful analytical data from the piezometers. By combining water quality data with equipotential data, chemical variation within the aquifer can be observed. R. Szentirmay of the Westhollow Research Center visited the site on the week of August 25, 1981. During this time, location personnel were trained in proper groundwater sampling procedures.

A Middleburg pump was used to evacuate ten pore volumes from each piezometer, before sampling. After pumping, a stainless steel bailer was used to obtain water samples. A teflon bailer was used to obtain water samples which would be analized for volatile organics.

Preservatives were added to water samples which were to be analized for applicable parameters (metals, oil and grease, cyanides, etc.). Some parameters such as pH, conductivity, and temperature were analized immediately on site. Sampling equipment was thoroughly washed and rinsed after use in each individual piezometer.

Water samples were stored in an ice chest at 4°C, until analyses were run. All of the parameters except total organic halogen (TOX) were evaluated at the refinery laboratories. Westhollow and an outside laboratory are presently evaluating water samples for TOX and pesticides. Controls were run to ensure proper analytical quality. Grease was inadvertently applied to all of the piezometers (threaded caps). The grease may cause certain evaluated parameters to be nonrepresentative of actual groundwater quality. Nonrepresentative parameters would correspond to components found in the grease.

After evaluating the analytical data contained in C. G. Wall's memorandum dated October 16, 1981 (Attachment IV), it was decided to utilize chloride (Cl^-), sulfate (SO_4^-), sodium (Na^+), and cyanide (CN) as the parameters that would best indicate groundwater quality within the aquifer. Initial TOX values for a few of the wells were found to be inconsistent, and were not used for this study.

Concentration trends within the aquifer are hydraulically and chemically dependent. Final evaluation was based upon concentration trends in relation to the background piezometer pair (P_{12}). A statistical survey (Fig. 7) with an N-1 weighting was used to help evaluate some of the chemical parameters. Overlays (Fig's. 8-13) were constructed to further evaluate concentration trends. Each block on the overlay shows a concentration factor (Cpi/Cp12) for both the upper and lower piezometer in each borehole. The blocks overlying P_{12}, however, indicate actual ppm concentrations. The evaluated parameter is listed in the center of each block. When the overlay is properly positioned (over the corresponding cross section), chemical trends (Cl^-, SO_4^-, Na^+, and CN) can be discerned.

Trend evaluation indicates that concentration changes are greatest on the southern side of the OFAP along line A-A'. Chloride and sulfate analyses were used, since salt concentrations in this area are higher than normal. Sodium trends indicate that this and other similar ions are mainly concentrated in the lower half of the aquifer. Cyanide trends reveal a 66.5 fold increase in concentration from P_{12}. Observed cyanide concentrations fall within present day acceptable limits, however. Piezometers screened within the lower clay indicate little or no contamination.

Summary and Conclusions

Groundwater in the vicinity of the didposal area generally flows towards the west. Based on the first set of analyses, it appears that leachate originating from the OFAP and SWDB is having a marginal impact on groundwater quality. Observed chemical concentrations increase slightly to the west of the disposal area, but the observed values are within established water quality standards.

Pumping wells located on the North Property (Fig. 6) are currently forming a combined cone of depression which intercepts contaminant plumes originating from the disposal area. As long as the present cone of depression is maintained, these conditions will continue to exist.

Currently, all water levels are measured semianually. In addition, the hydraulic gradient between select wells is measured monthly. These data are adequate to monitor the cone of depression.

If we can be of further assistance, please advise.

C. C. Stanley

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CCS/hg

cc: <u>w/attachments</u>
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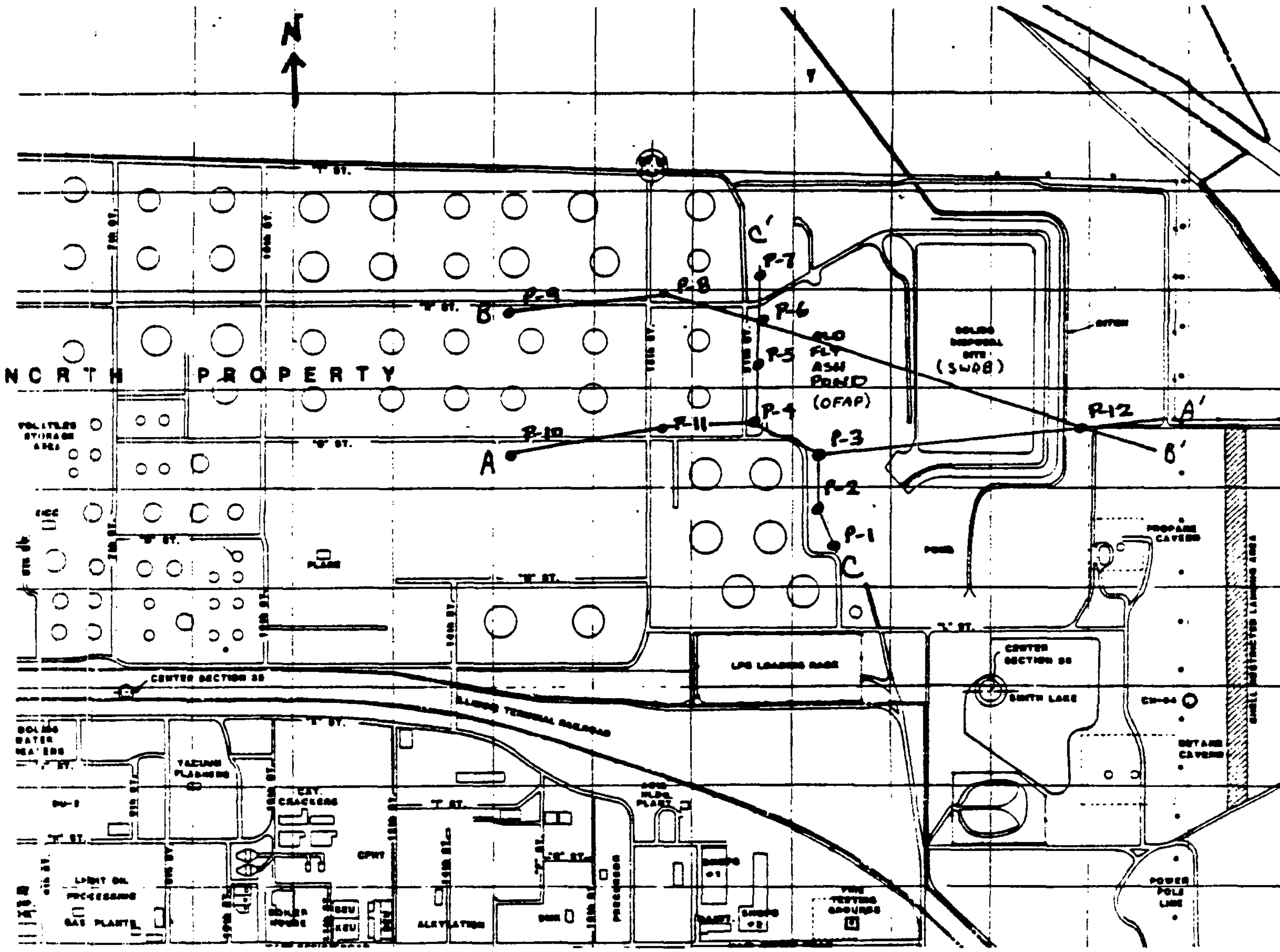
HS&E IS(2)

FIGURE 1

LOCATION OF PIEZOMETERS
+
Cross Sections



● DENOTES PIEZOMETER PAIR

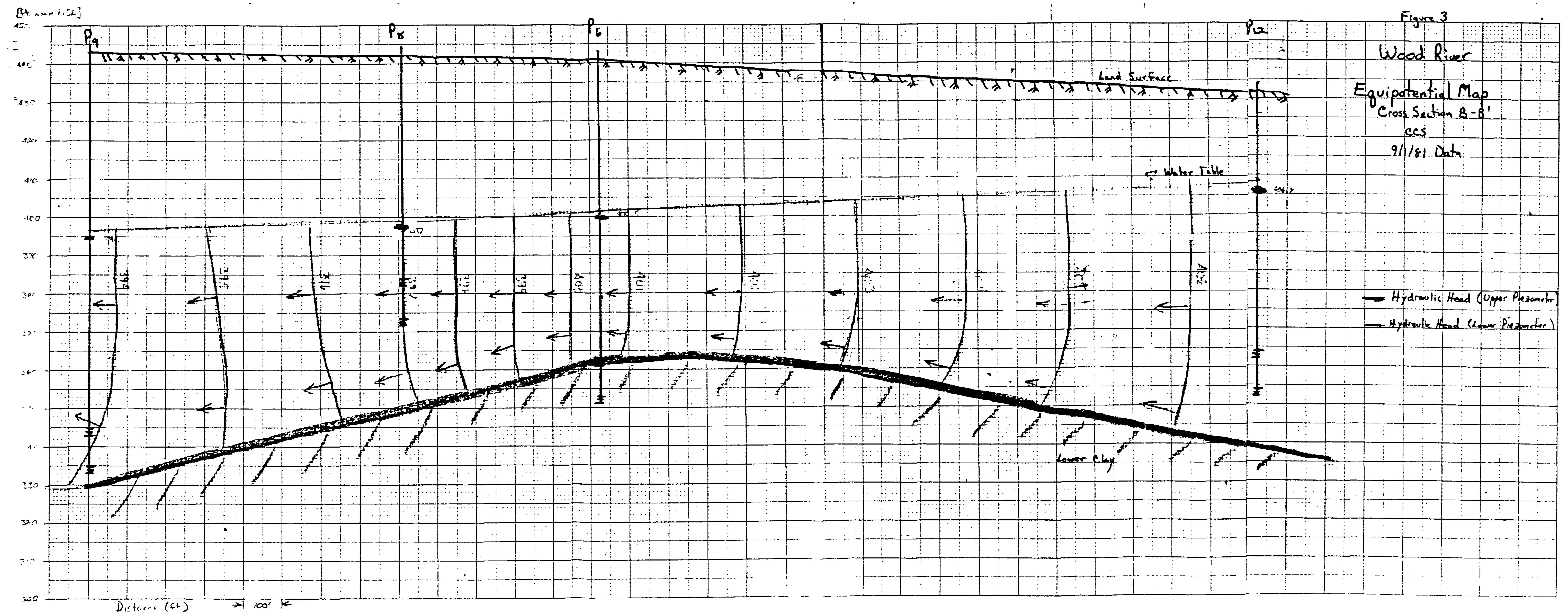


Figure 3
Wood River
Equipotential Map
Cross Section B-B'
ccs
9/1/81 Data
Land Surface
Water Table
Hydraulic Head (Upper Piezometer)
Hydraulic Head (Lower Piezometer)
Lower Clay
Distance (ft)
100'

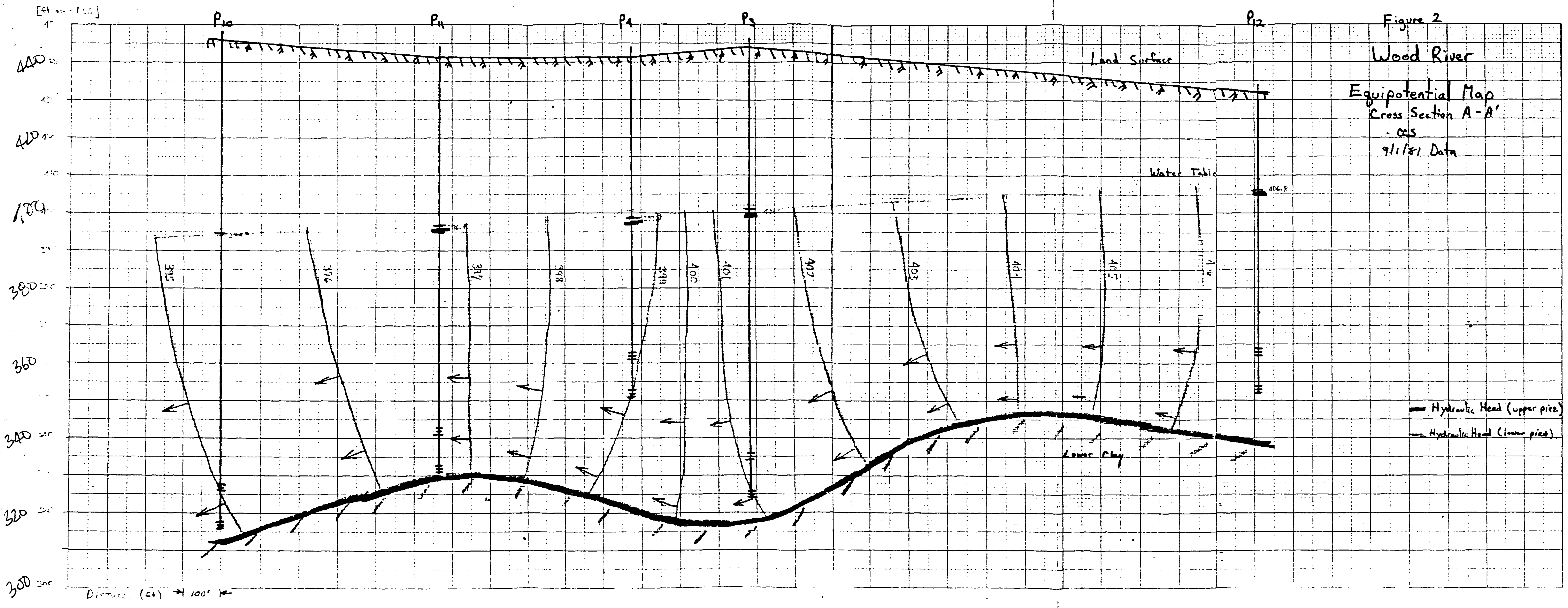


Figure 2
Wood River
Equipotential Map
Cross Section A-A'
- ccs
9/1/81 Data
P10
P11
P4
P3
P12
Land Surface
Water Table
Lower Clay
Hydraulic Head (upper piez)
Hydraulic Head (lower piez).
440
420
400
380
360
340
320
300
395
396
397
398
399
400
401
402
403
404
405
Distance (ft) → 100' ←

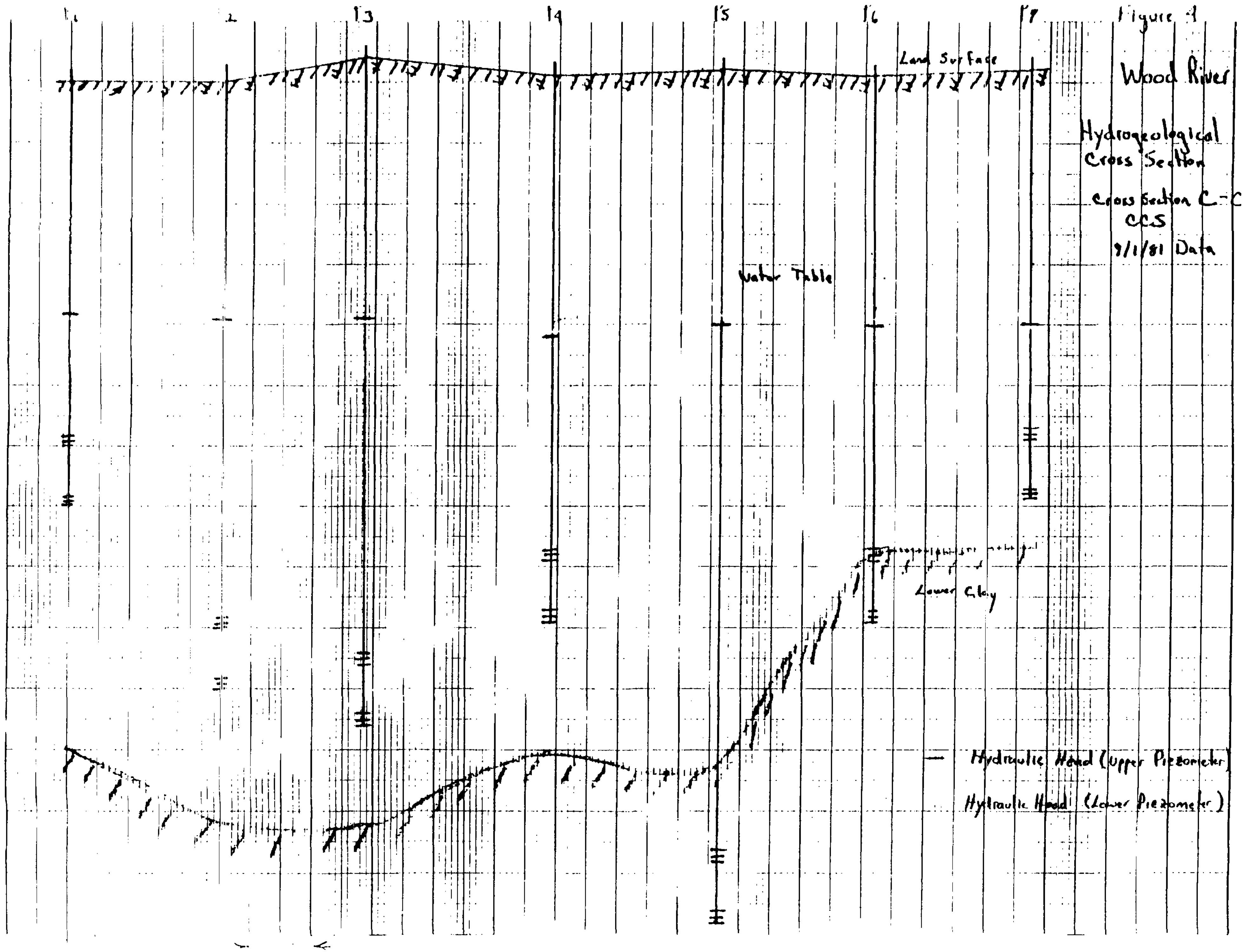
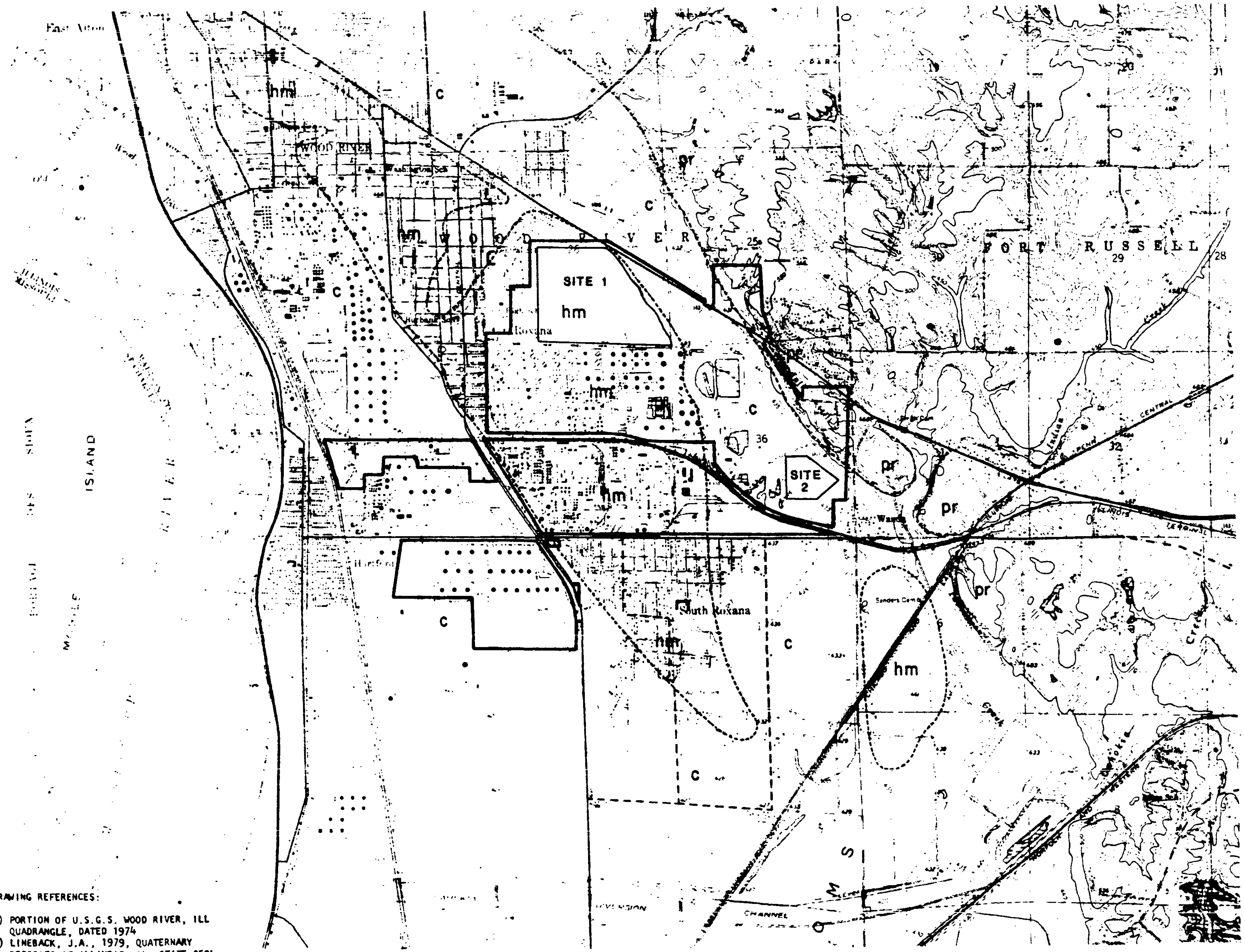


Figure 9
Wood River
Hydrogeological Cross Section
Cross Section C-C'
CCS
9/1/81 Data
Land Surface
Water Table
Lower Clay
Hydraulic Head (upper Piezometer)
Hydraulic Head (Lower Piezometer)

Figure 5



LEGEND:

GEOLOGY

WISCONSINAN AND HOLOCENE

c — CAHOKIA ALLUVIUM
-floodplains, channels, modern rivers mostly poorly sorted sand, silt or clay and local sandy gravel

WISCONSINAN

pr — PEORIA LOESS AND ROXANA SILT
-windblown silt, local lenses of fine gravelly sand

hm — MACKINAW MEMBER OF HENRY FORMATION
-sand and gravel, generally well sorted, bedded. Terrace remnants -former valley trains

--------- APPROXIMATE GEOLOGIC CONTACT

——— SHELL OIL COMPANY PROPERTY BOUNDARY

1000 0 1000 3000 5000 7000 FEET

DRAWING REFERENCES:

1) PORTION OF U.S.G.S. WOOD RIVER, ILL QUADRANGLE, DATED 1974
2) LINEBACK, J.A., 1979, QUATERNARY DEPOSITS OF ILLINOIS: IL. STATE GEOL. SURVEY, MAP. SCALE 1:500,000.

SHELL OIL COMPANY
WOOD RIVER REFINERY

SURFICAL DEPOSITS

Dames & Moore

Figure 6 is a Water Table Map dated March, 1981, and is included in Volume III.

Figure 7

STATISTICAL SURVEY

	Mean ($\bar{x}$)	Standard Deviation (σ [N-1])	Variance (σ^2 [N-1])
Groundwater Contamination Parameters			
pH	7.4	0.4	0.17
Specific Conductance (mho/cm @25° C)	1694	641	410375
Groundwater Quality Parameters			
o Chloride (mg/l)	305	148	21860
Phenols (mg/l)	0.015	0.045	0.002
o Sodium (mg/l)	199	92	8406
o Sulfate (mg/l)	337	140	19689
Drinking Water Parameters			
Arsenic (mg/l) (0.05 Standard)	0.014	0.006	4×10^{-5}
Other Test Parameters			
Volatile Organics (ppm, V/V)	9	34	1127
o Cyanide (mg/l)	0.018	0.034	0.001

Figure 8

Chloride and Sulfate Trend Overlay

(Cross Section A - A')

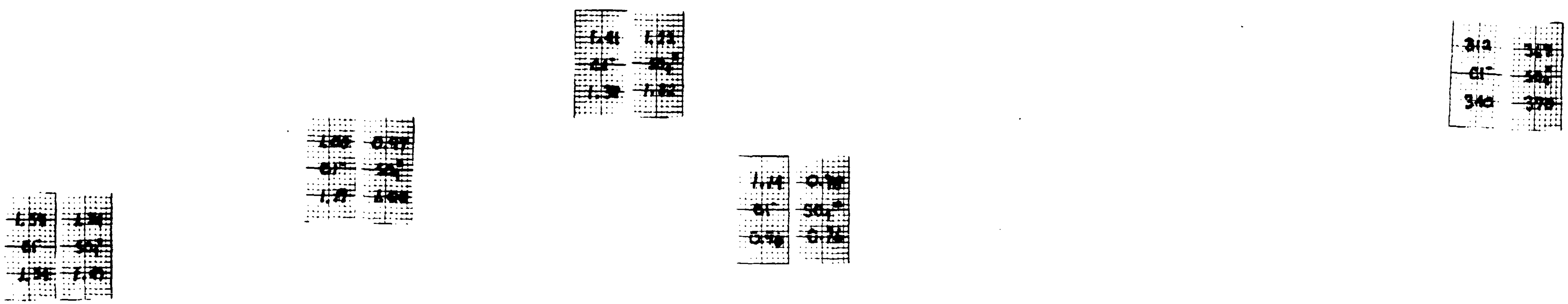


Figure 9

Chloride and Sulfate Trend Overlay

(Cross Section B - B')

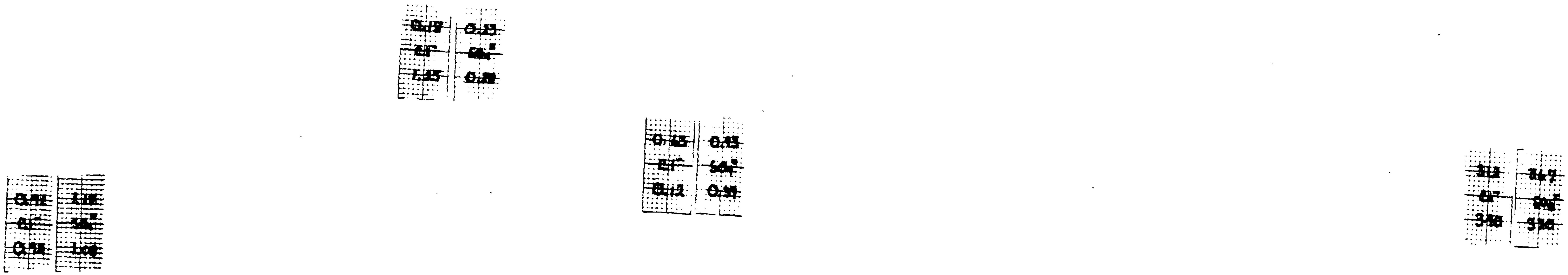


Figure 10

Chloride and Sulfate Trend Overlay

(Cross Section C - C')

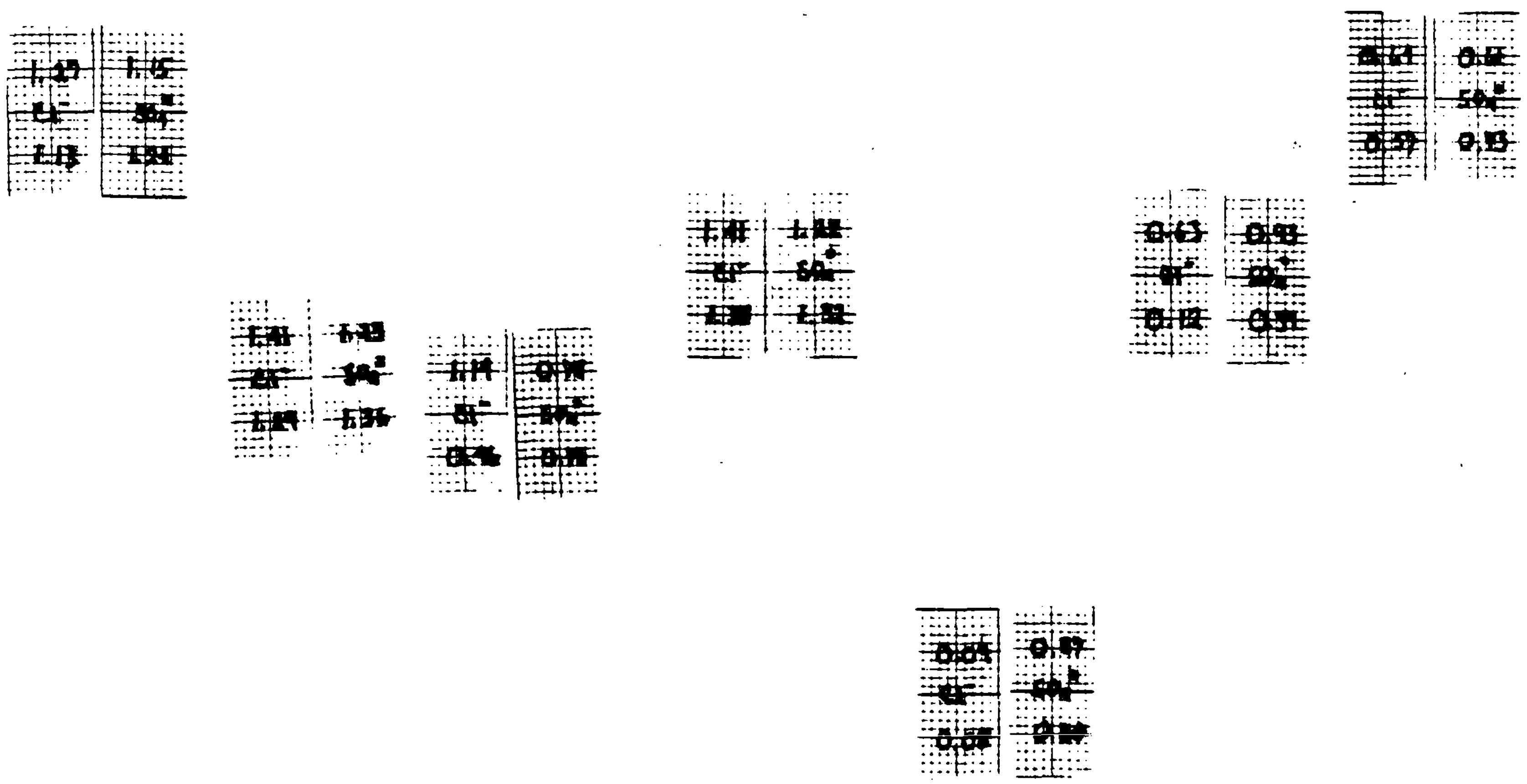


Figure 11

Cyanide and Sodium Trend Overlay

(Cross Section A - A')

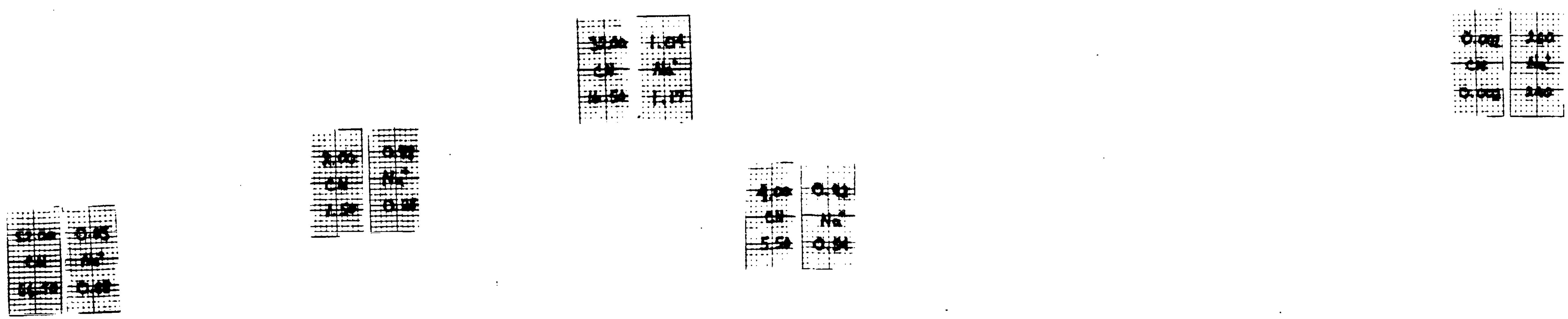


Figure 12

Cyanide and Sodium Trend Overlay

(Cross Section B - B')

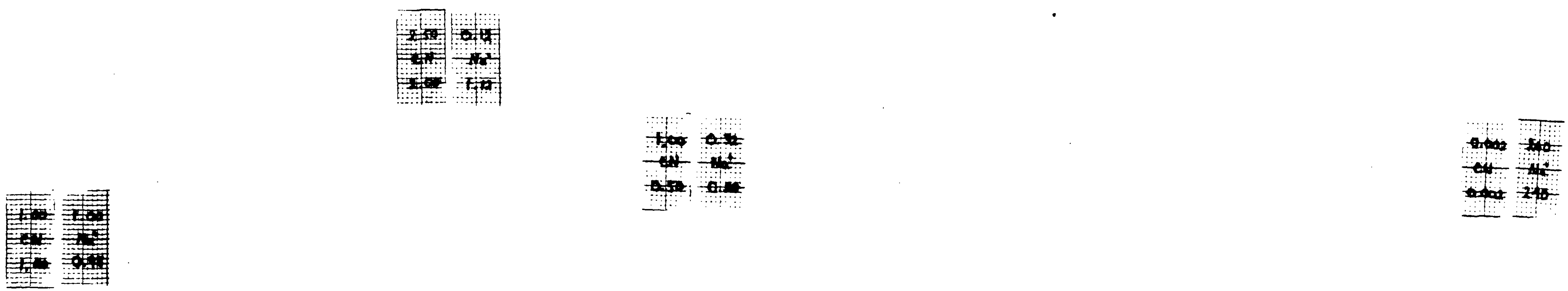


Figure 13

Cynaide and Sodium Trend Overlay

(Cross Section C - C')